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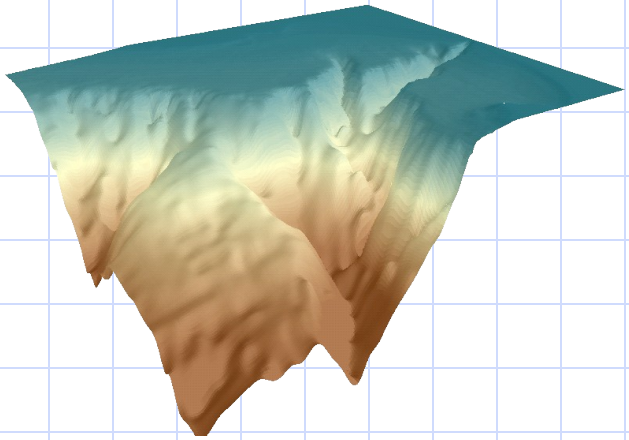
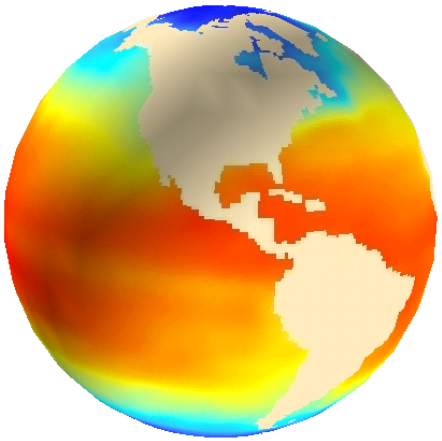
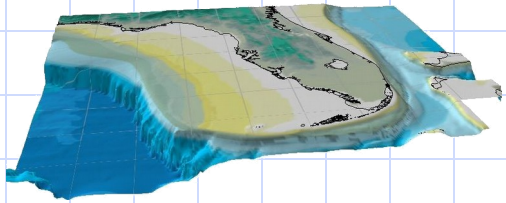
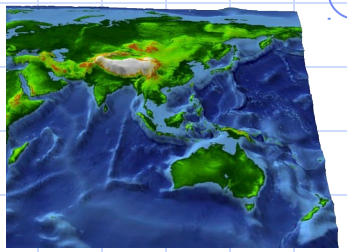
Geospatial Information System (GIS) for Physical Based Modelin g and Simulation

Dr. Peter Chu
CDR Ming-Jer Huang









Outline

GI&S and the Navy

GIS for Warfighters

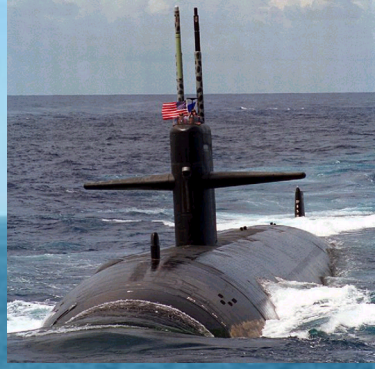
(OC3902 GI&S)

GIS for Modeling & Simulation

Case Study: Ship Simulation

GIS in MOVES

GI&S and the Navy



RADM Richard D. West
Navigator of the Navy

GI&S – the Navy's Needs

"Geospatial Information and Services (GI&S) is the collection, information extraction, storage, dissemination, and exploitation of geodetic, geomagnetic, imagery, gravimetric, aeronautical, topographic, hydrographic, littoral, cultural, and topographic data accurately referenced to a precise location on the earth's surface."

Joint Publication 2-03 *-- Joint Tactics, Techniques and Procedures for Geospatial Information and Services Support to Joint Operations, 31 March 1999*

Legacy, Today and Beyond

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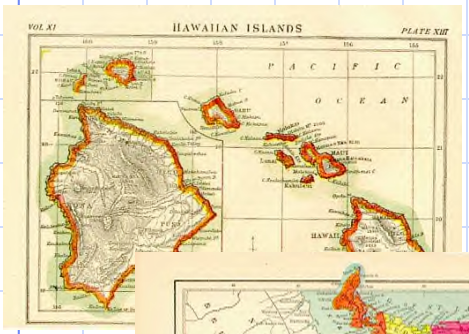
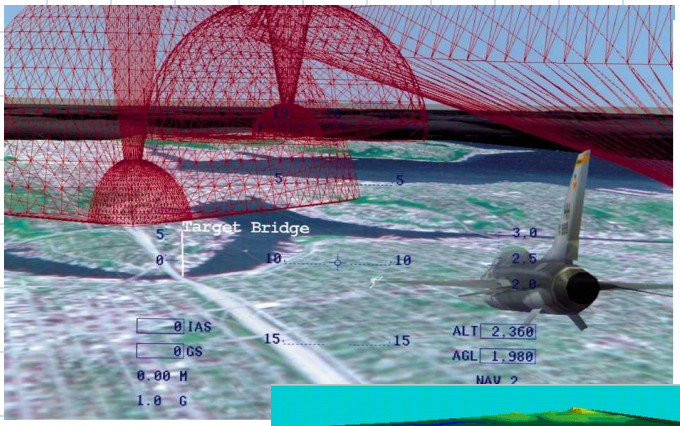


The Old



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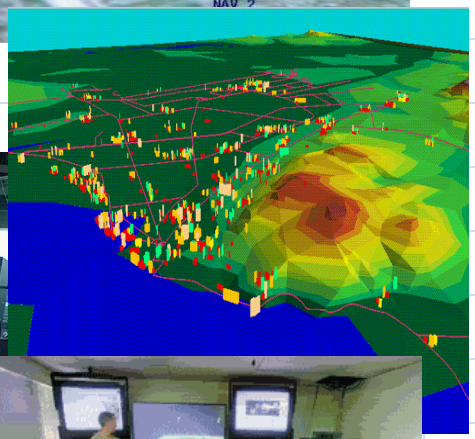

What is GI&S?

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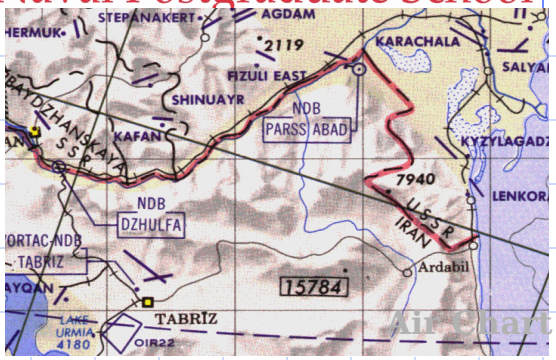
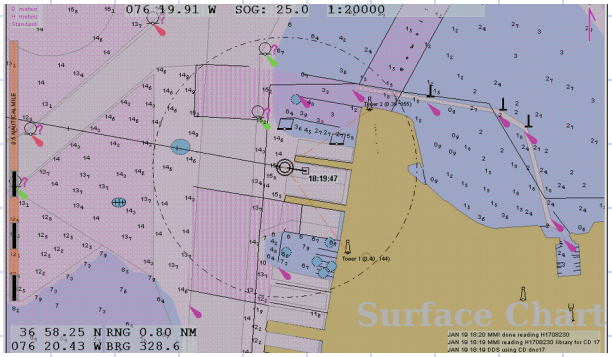
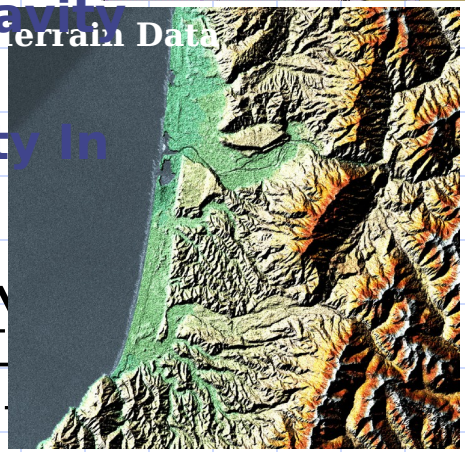
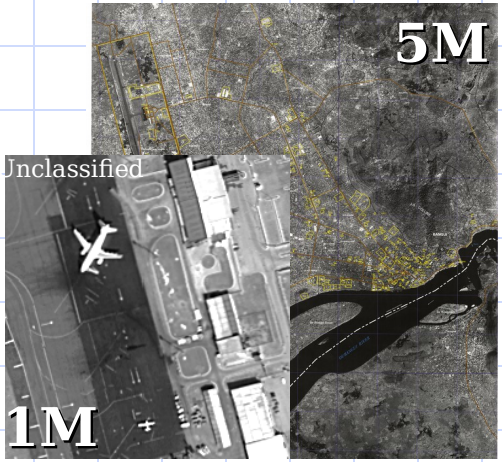
- **Geospatial Information and Services: Geospatial Information is referenced to a specific location on the earth**
- **Examples include:**
  - **Maps & charts**
  - **Digital Elevation Maps**
  - **Imagery**
  - **Geophysical Data (gravity, magnetics)**
  - **Nautical & Aero Safety Information**









Why Digital GI&S?

Time

- Quicker crisis response
- Digital transmission of information – Enhances safety of navigation

Accuracy

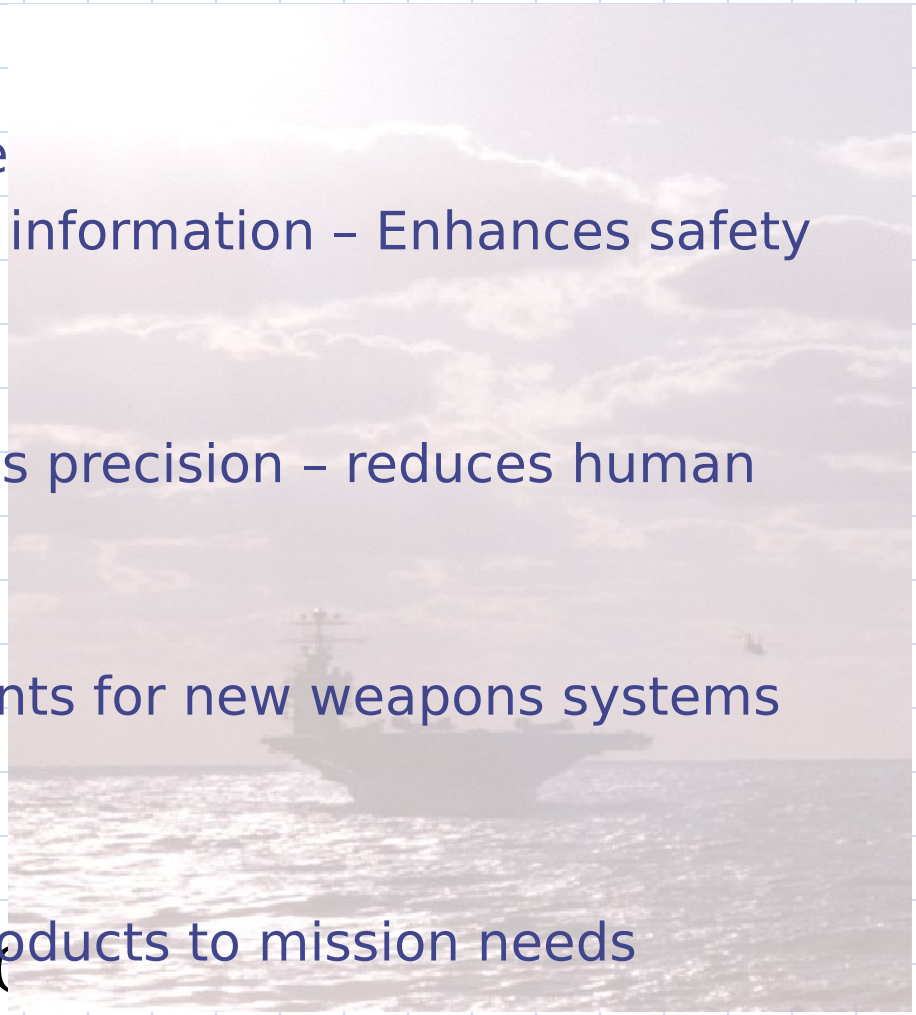
- Digital source increases precision – reduces human error

Utility

- Meets GI&S requirements for new weapons systems
- Basis for COP

Flexibility

- Allows user to tailor products to mission needs



GI&S Support to the Warfighter

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Aeronautical Information

- Charts
- Flight Safety/Notice to Airmen
- Escape and Evasion
- Publications

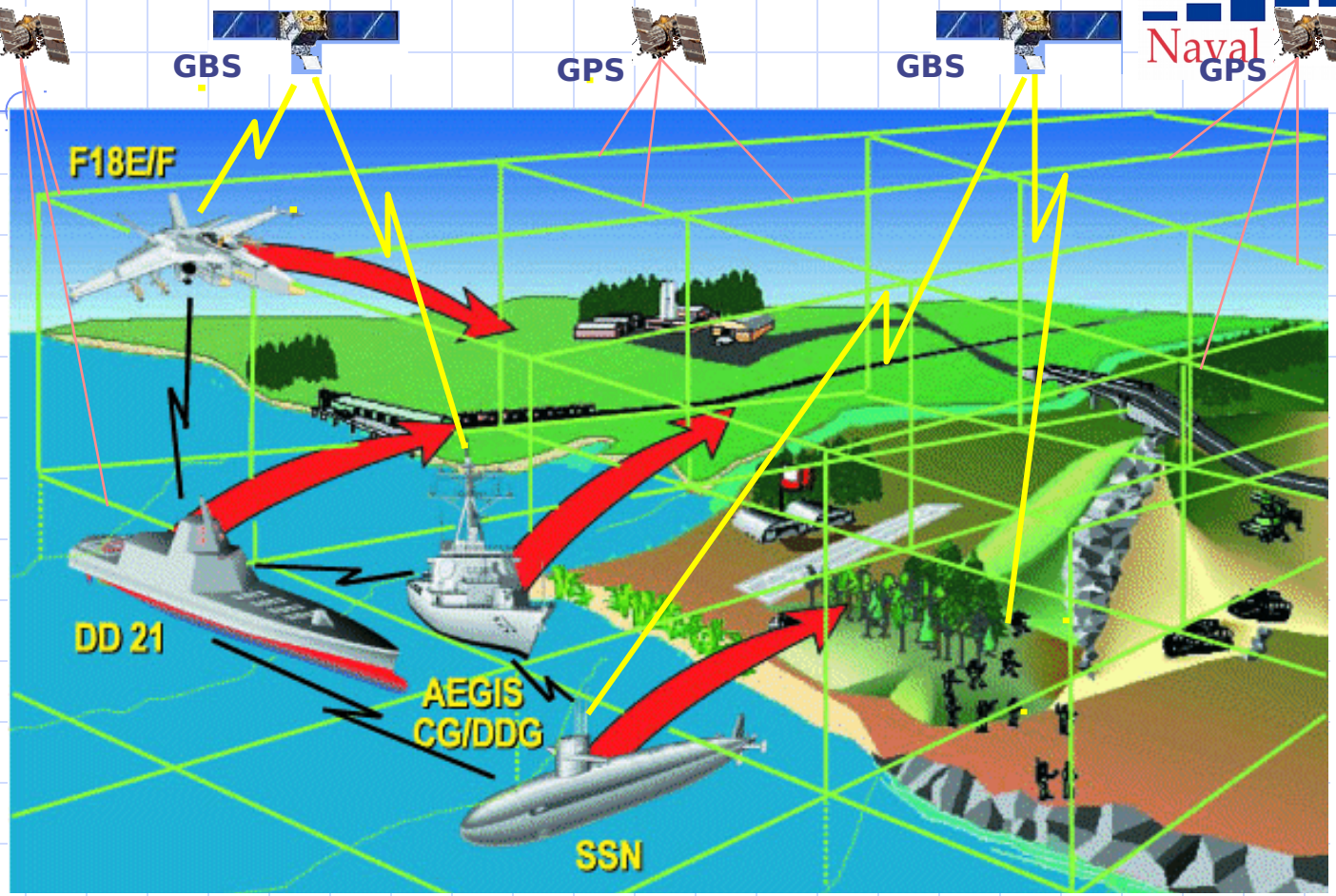
Hydrographic Information

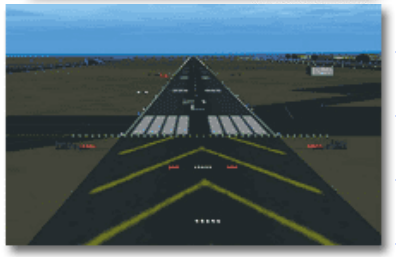
- Combat Charts
- Digital Nautical Chart
- Surface/Sub-surface Navigation Charts
- Nautical Safety/Notice to Mariners
- Publications

Topographic Information

- Topographic Line Maps/Raster/Vector
- City Graphics
- Terrain Analysis
- Controlled Image Base

4-D Cube Ops Environment





3-D Battle space integrates C4I for all platforms and provides information superiority across the 4th dimension – time

Components of GI&S

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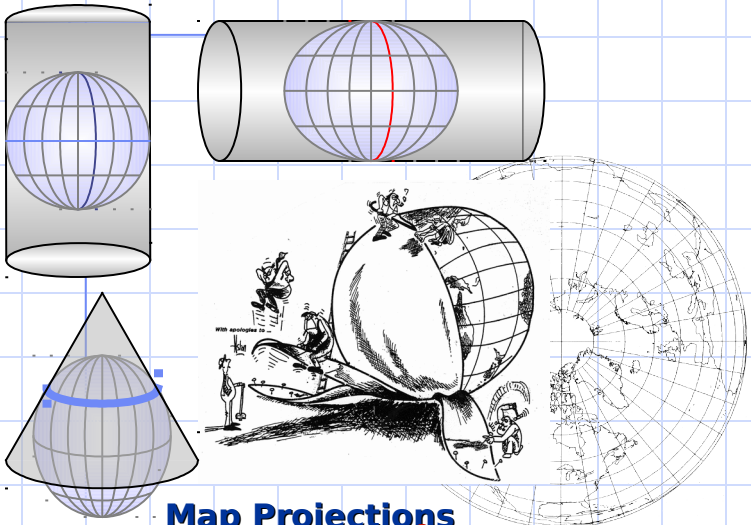
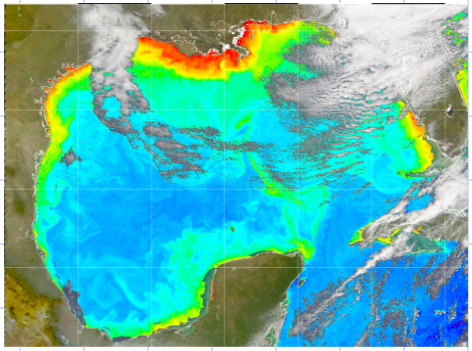
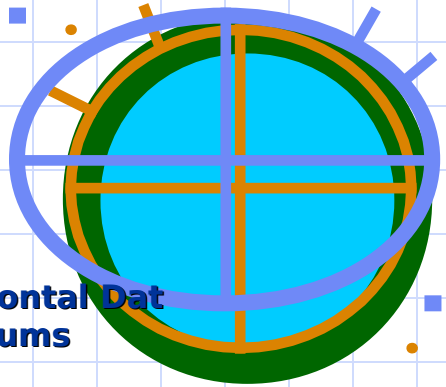


Map Projections

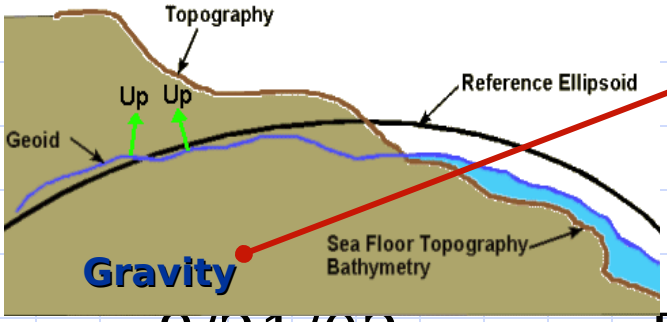


Remote Sensing

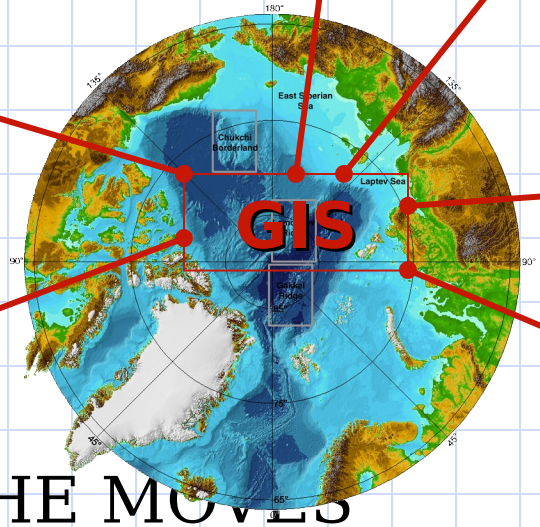
GPS

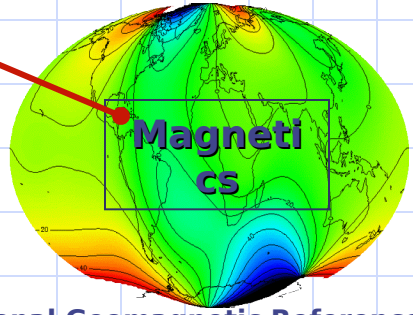


Horizontal Datums



Gravity





Magnetics

International Geomagnetic Reference Field (IGF

GIS in MOVES

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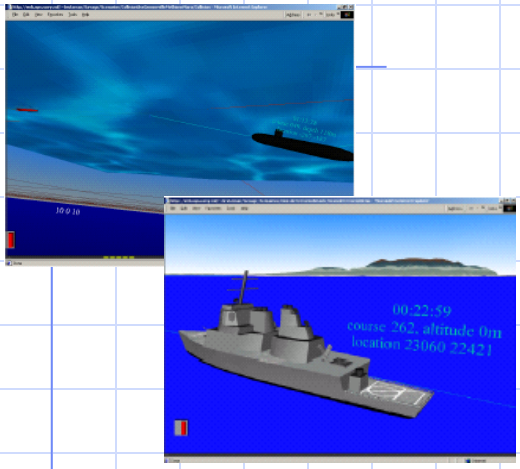
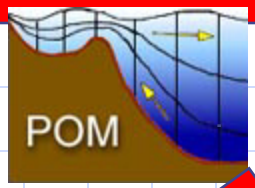
GIS Capability: Data Fusion & Analysis

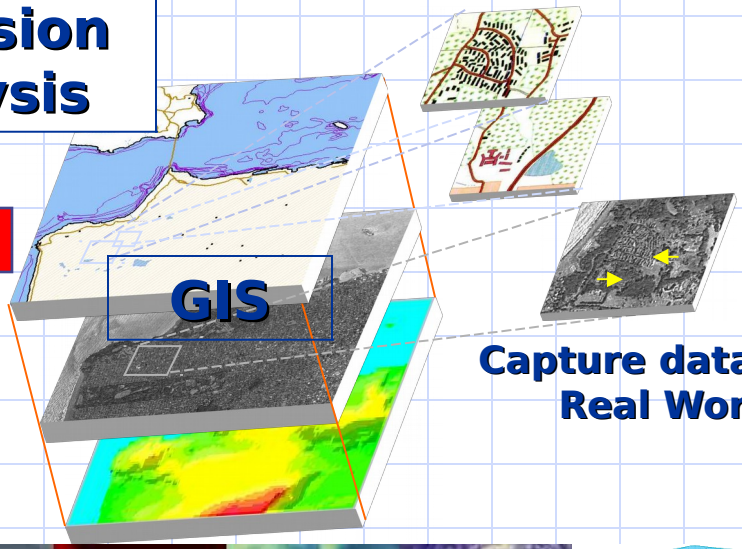
GIS Data Models



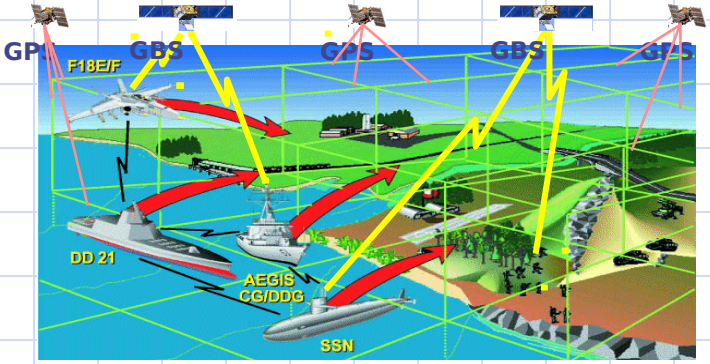
Virtual World Modeling & Simulation Support

Physical-Based Modeling

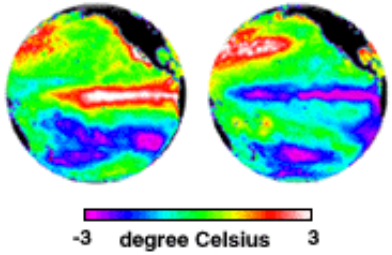


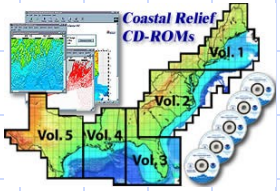


Capture data from Real World



4D Cube Ops Environment





Environmental Observations & Forecasting

GIS for Environmental Data Management

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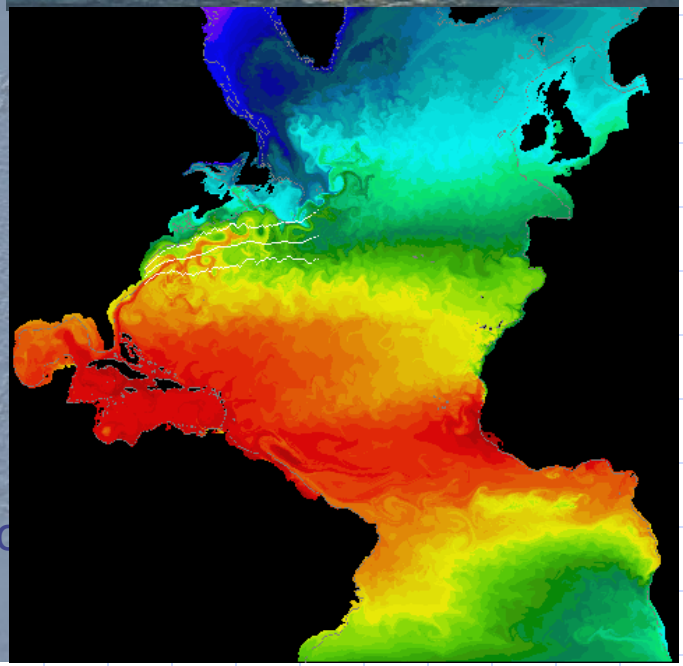
- Physical-Based Modeling
  - Environmental Observations
    - Bathymetry
    - Temperature, Salinity, Sound Speed
    - Ocean Current
    - Sediment
  - Physics
    - Ocean/Atmospheric dynamics
    - Boundary Conditions
    - Numerical Methods
  - Ocean Models
    - POM: Terrain-following Ocean Model
    - MICON: Isopycnic Model
    - MODAS:Data Assimilation Model
- GIS functions
  - Environmental & model data integration
  - Model output presentation



Environmental Data Sets

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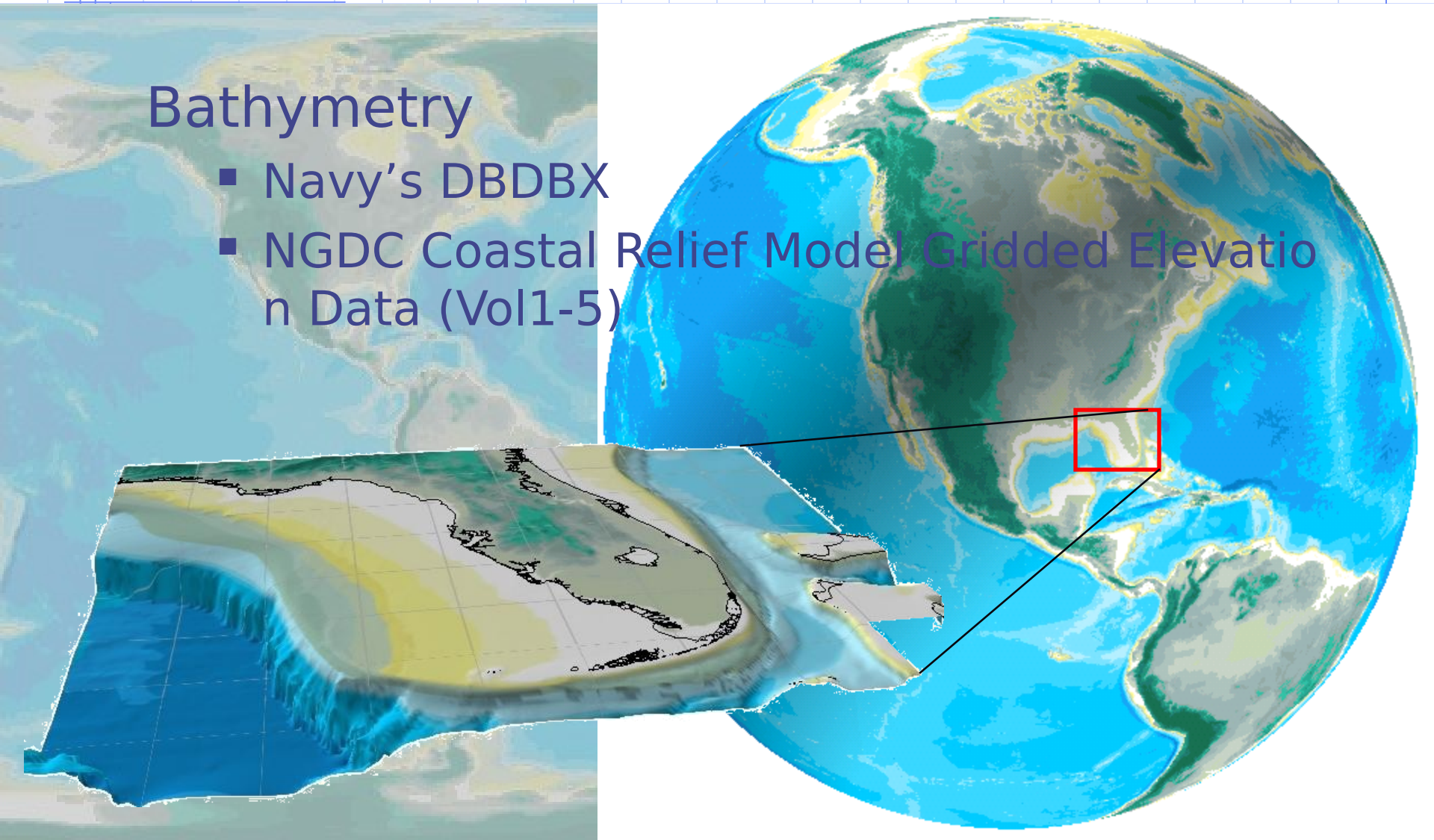
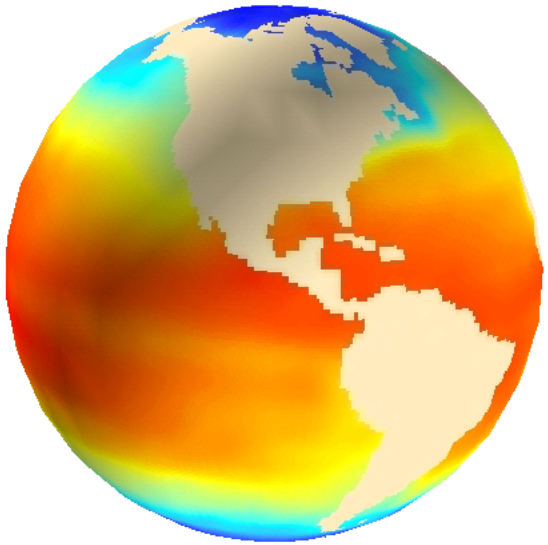
Bathymetry

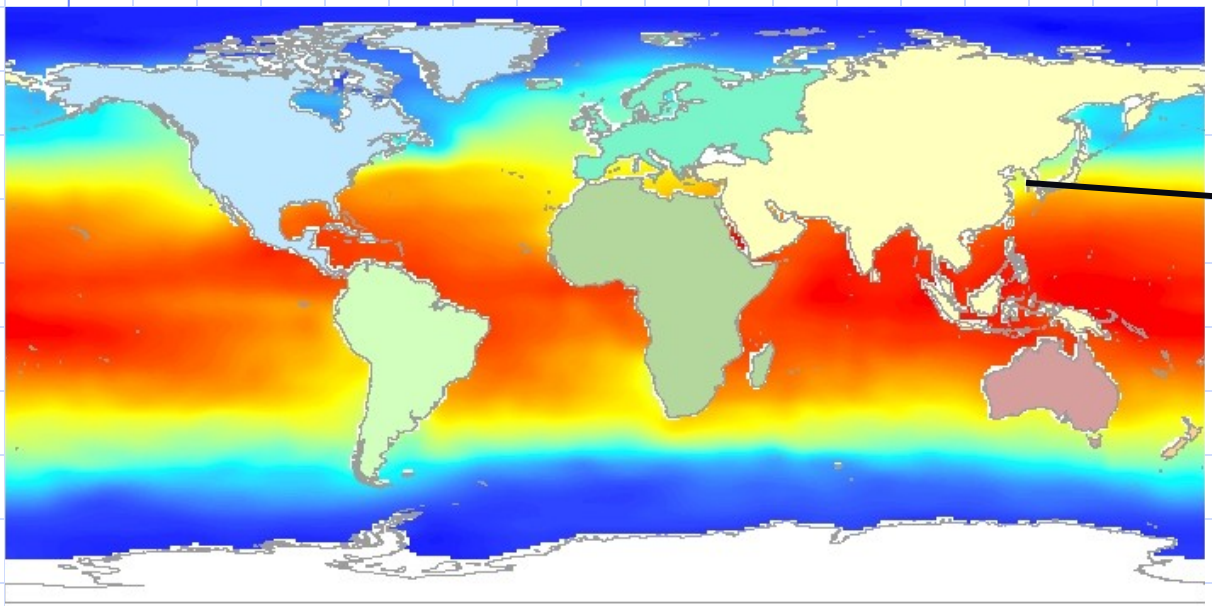
- Navy's DBDBX
- NGDC Coastal Relief Model Gridded Elevation Data (Vol1-5)

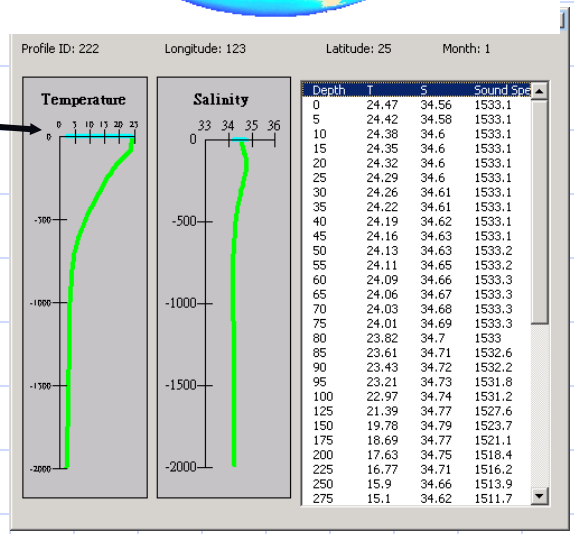


Environmental Data Sets (1)

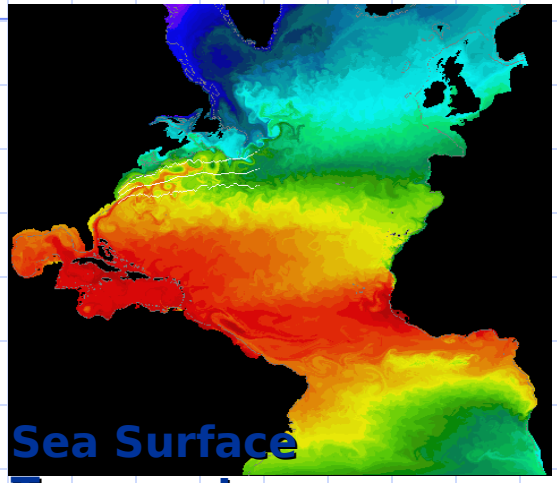
- Temperature & Salinity
  - Data Sources
    - Navy's MOODS
    - NODC data sets(WOA 1994 & 1998)
  - GDEM (Navy)
    - Global monthly Temperature and Salinit Climatology



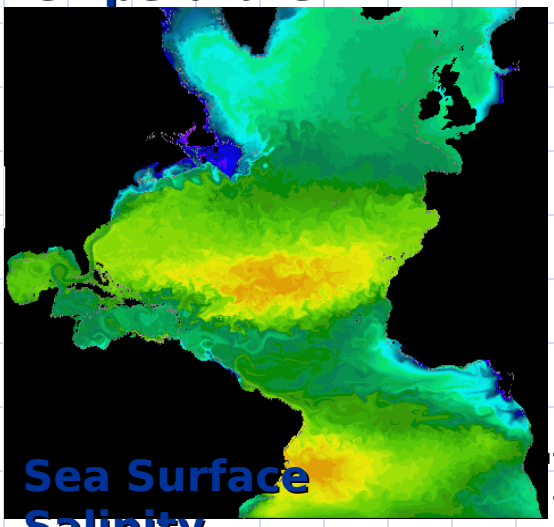




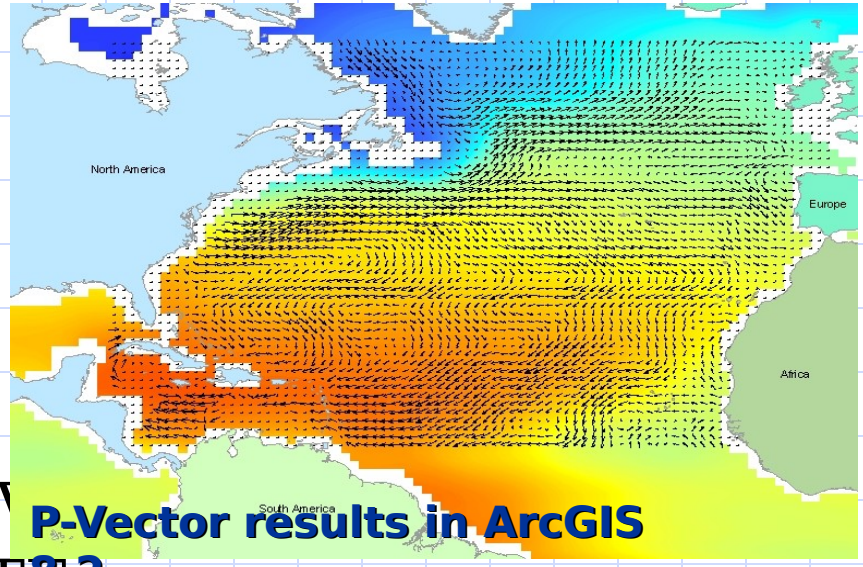
Environmental Data Sets (2)



Sea Surface Temperature



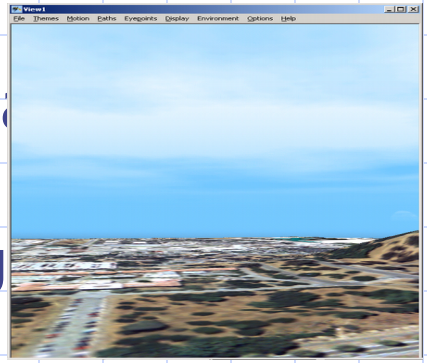
Sea Surface Salinity



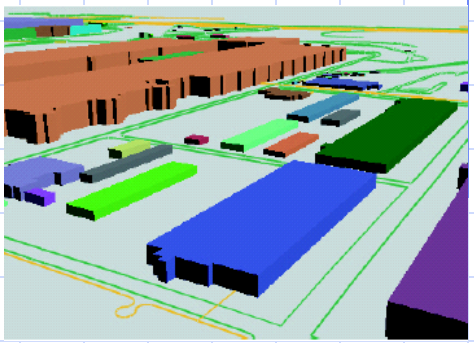
P-Vector results in ArcGIS 8.2

GIS for M&S

- Real World Data Integration
  - Remote Sensing Images
  - Terrain Data
  - Ground Features
- Model Building for Virtual Simulations
  - Open Flight (Site-Builder 3D)
  - VRML
    - VRML97
    - GeoVRML



Site Builder 3D result



Building footprints extruded by building height

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ArcScene 8.2 Live

Case 1
Ship Simulation

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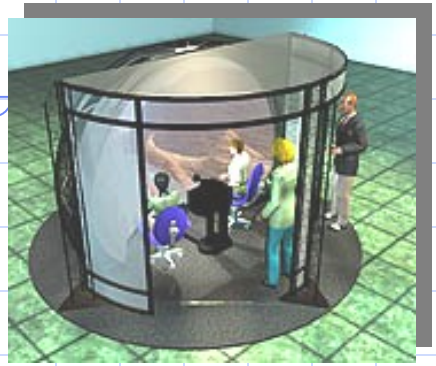
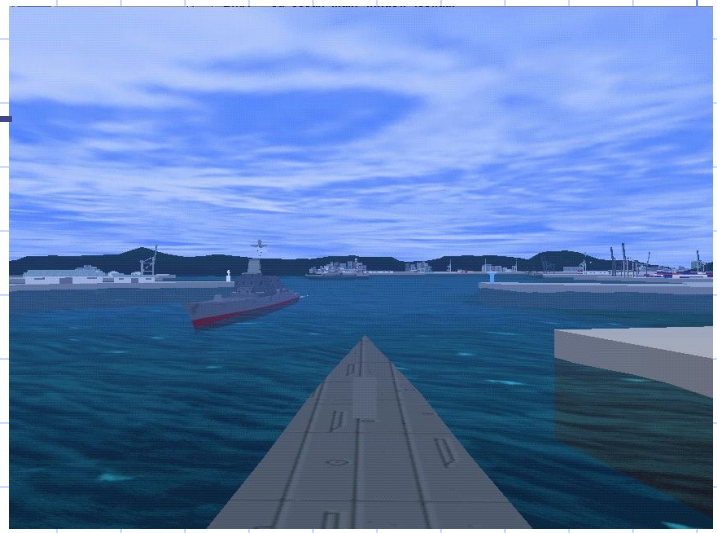
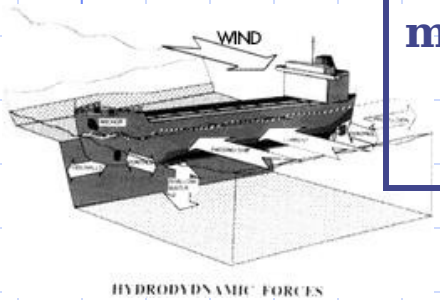


Vision Station



Ship's Hydrodynamic Model

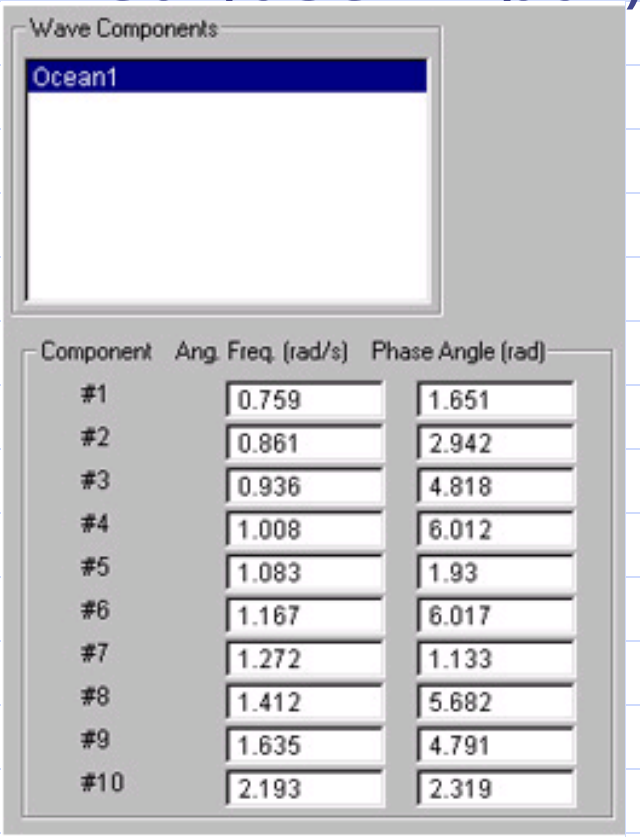
VEGA (Harbor model Ship, lighthouse Marine Effe



Instruments /Computer interface

Ocean Waves in VEGA

Default wave components in VGEA-Marine are predefined (user input)



Wave Components in VEGA

Instantaneous Wave Height formula used in VEGA marine

$$\zeta = Tide + \zeta_0 \sum_{i=1}^{10} \cos(k_i(x\sin\chi + y\cos\chi) + \Omega_i \omega_s t + \varphi_i)$$

where

$Tide$ = **average height above mean sea level**

ζ_0 = **0.112 *Hs*, average wave power, *Hs* = significant wave height for the sea state [m]**

$k_i = \frac{(\Omega_i \omega_s)^2}{g}$ **(from the deep-water dispersion relation)**

g = **the acceleration due to gravity = 9.81 [m/s^2]**

χ = **wave direction [0..2π]**

Ω_i = **non-dimensional angular frequency of the *ith* component**

$\omega_s = \frac{2\pi}{T_s}$ = **angular frequency of sea state**

T_s = **the modal period of the sea state**

t = **time [s]**

φ_i = **phase angle of the *ith* component [rad]**

deep water dispersion relation

$$\lambda = \frac{T^2 g}{2\pi}$$

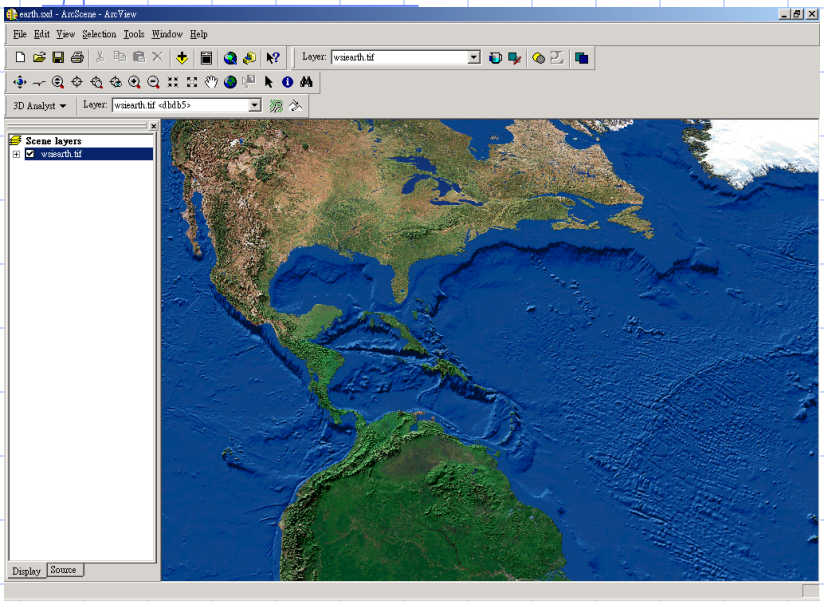
Future Work

Software Development for Data Conversion and Management (Web3D GIS)

Linkages Between Navy Ocean Environmental Models, Warfare Models Using GIS (Battlespace Environment)

Environmental Effects on M&S

Web-3D GIS


earth.sxd - ArcScene - ArcView
File Edit View Selection Tools Window Help
Layer: wsearth.tif
3D Analyst
Layer: wsearth.tif <ihdb5>
Scene layers
wsearth.tif
Display
Source

VRML

Features:

- Terrain with 1m satellite image texture
- Simplified terrain using TIN
- Buildings colored by different categories
- Plant trees by point features